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# ADULT OVERWINTER MORTALITY IN *OSMIA LIGNARIA PROPINQUA* CRESSON (HYMENOPTERA: MEGACHILIDAE)

Richard W. Rust
Department of Biology and Program in Ecology,
Evolution and Conservation Biology,
University of Nevada, Reno, Nevada 89557

*Abstract.*—Adult *Osmia lignaria propinqua* Cresson from Reno, Nevada that were overwintered in Logan, Utah had increased winter mortality, reduced emergence, and lower reproductive success compared to a similar population of bees from Logan, Utah. Both lower average monthly temperatures and extreme minima were responsible for the winter loss.

*Key Words.*—Insecta, *Osmia,* overwinter, mortality

Unusual events, such as atypical precipitation or temperature patterns, were invoked by researchers to explain unusual events in field data in 9% percent of insect studies (n = 54) and in 9% of all studies (n = 354) analyzed by Weatherhead (1986). When separated by ecosystem, unusual events were used to explain 5% (38) of temperate, 12.5% (8) of tropical, and 25.0% (8) of desert insect studies (Weatherhead 1986). These unusual events may be more common than expected, greater than one in 20 chance, and may function to keep populations below their carrying capacity (MacArthur 1972, Wiens 1977).

Here I present both observational and experimental data on the effects of unusual density independent temperature events on the overwinter losses in two populations of the bee, *Osmia lignaria propinqua* Cresson. One population (Logan, Utah) with frequent exposure to extreme low winter temperatures showed little measurable winter mortality. Whereas, another population (Reno, Nevada) when exposed to extreme low winter temperatures showed reduced survivorship.

*Osmia l. propinqua* overwinter as adults inside the larval cocoon (Rau 1937, Krombein 1967, Rust 1974, Torchio 1989). Pupation occurs during June and July, and by August all individuals that successfully complete immature development are adults. In the laboratory, bees are successfully overwintered at 4° C until their release in apple, prune, or almond orchards the following spring (5 to 6 months) (Torchio 1976, 1982, 1985).

## Materials and Methods

Bees used in this study were from trap-nests placed out in Reno and Logan during the spring and summer of 1988. In September, trap-nests were recovered and some Reno trap-nests were moved to Logan for overwintering. In Reno, bees were provided with pine blocks drilled with 5, 6, 7, 8, and 9 mm diameter holes to a depth of 135 to 140 mm (Rust 1990). In Logan, bees were provided with drilled wooden blocks with 7 mm by 140 mm paper straw inserts (Torchio 1976, 1985). Nests were overwintered in an unheated, metal storage building on the Utah State University campus, Logan, Utah. In March, the nests were brought into the laboratory for examination and data recording. Nests from Reno con-

Table 1. Overwintering and emergence parameters for two populations of *Osmia lignaria propinqua* Cresson. One population from Reno, Nevada and the other Logan, Utah. Both populations were overwintered in Logan, Utah. All paired data sets are significantly different at $P \leq 0.001$. Data presented are means and standard deviations.

| Parameter | Males | | Females | |
|---|---|---|---|---|
| | Reno | Logan | Reno | Logan |
| Weight—mg | 37.3 ± 7.3 | 65.7 ± 24.4 | 61.4 ± 22.6 | 92.3 ± 43.3 |
| Hours emerge | 28.9 ± 9.8 | 59.7 ± 15.8 | 50.0 ± 18.5 | 106.4 ± 22.1 |
| Hours lived | 78.0 ± 21.5 | 140.4 ± 28.8 | 88.7 ± 19.7 | 170.4 ± 42.9 |
| % weight loss | 17.6 ± 8.0 | 40.1 ± 6.1 | 18.2 ± 6.4 | 33.3 ± 6.8 |

tained both dead adults and live adults that showed limited movement when exposed to laboratory room temperature (21 ± 2° C). Individuals from 19 randomly selected nests from each test site were left inside their cocoons, weighed (0.1 mg) and placed in individual plastic vials (21 mm diameter × 40 mm). These individuals were placed in a temperature cabinet held at 21° C ± 1.0° C, 70 ± 5% relative humidity, and 24 h dark. Individuals were checked at 12 h intervals for emergence from their cocoon and length of life. Cocoons were removed, weighed and adult weight was determined by subtraction. Adult dead weight was also measured.

Climatic data for Reno and Logan were assembled for the winter months (October through March) (USDC-NOAA 1949–1991; USDC-NOAA 1988–1989).

Males and females from Reno and Logan were compared for emergence weight, hours to emerge, hours lived and percent weight loss by $t$-test (Zar 1974). Mean monthly minimum temperatures for October through March for both sites were also compared by $t$-test.

## Results

The 19 Reno nests contained 77 cells (40 males and 37 females) with adult bees of which 11 (six males and five females) were dead when opened in March. The 19 Logan nests contained 79 live individuals (56 males and 23 females). Both male and female *O. l. propinqua* from Reno were significantly lighter at emergence, required less time to emerge form their cocoons, lived a shorter period of time, and had less weight loss from emergence until death than Logan individuals (Table 1).

Twice during the overwintering period (October to March) the populations experienced six day periods (24 to 29 Jan and 5 to 10 Feb) of minimum temperatures at or below −17.0° C with a minimum low of −27.2° C (7 Feb).

Mean minimum temperatures over a 30 year period were significantly lower in Reno during October (−0.3 ± 1.0° C and 3.6 ± 2.2° C; $t = 7.73$, df = 58, $P < 0.001$) and November (−3.7 ± 2.1° C and −2.4 ± 2.0° C; $t = 2.45$, df = 58, $0.02 > P > 0.01$). Whereas, Logan temperatures were lower during January (−8.7 ± 3.2° C and −6.6 ± 2.5° C; $t = 2.79$, df = 58, $0.01 > P > 0.005$) and February (−6.6 ± 3.0° C and −4.2 ± 1.8° C; $t = 3.84$, df = 58, $P < 0.001$). There was no difference in December (Reno −6.8 ± 2.8° C and Logan −7.2 ± 2.1° C; $t = 0.44$, df = 58, $P > 0.50$) or March (Reno −2.8 ± 1.5° C and Logan −3.1 ± 2.1° C; $t = 0.56$, df = 58, $P > 0.50$) (Fig. 1). The 30 year monthly minimum temperatures

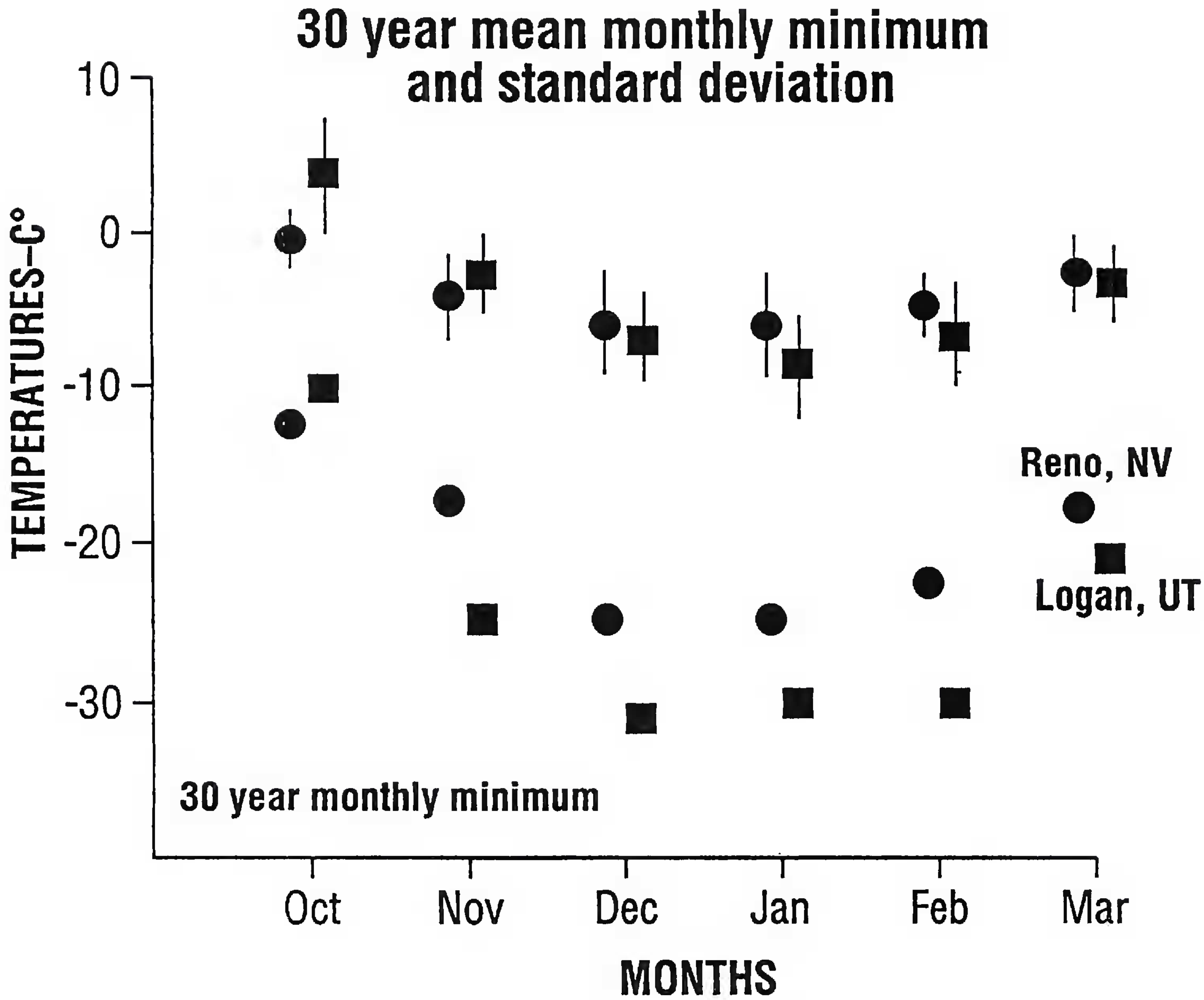


Figure 1. Thirty year mean and standard deviation of the monthly temperatures for October through March for Logan, Utah and Reno, Nevada and the 30 year monthly minimum temperatures.

were from four to eight degrees lower in Logan from November through February (Fig. 1).

## Discussion

The Reno population of *O. l. propinqua* experiencing lower winter temperatures in Logan had an increased adult winter mortality, reduced emergence longevity, and limited offspring production (Rust & Torchio 1991) when compared to the Logan population exposed to the same overwintering conditions. Several questions emerge about these observations and measurements. First, do the temperature differences between Logan and Reno allow for adaptation of Logan bees to colder winter condition but not the Reno bees? Second, how often, if ever, have the Reno bees been exposed to these cold temperatures? The mean monthly winter minimum temperatures for Logan and Reno were somewhat similar, but the recorded monthly minimums were colder by 4° to 8° C in Logan during four of the six winter months. This suggests selection and possible adaptation to lower cold temperatures in Logan bees.

If we assume an event is rare, as measured statistically at $P < 0.05$, then one would expect −27.2° C in one of 20 years. The coldest recorded minimum temperature in Reno, Nevada was −28.3° C in January 1890 (USDC-NOAA 1974) and from 1949 to 1991 the coldest Reno, Nevada temperature was −26.6° C. This low temperature was recorded in three of the 42 years ($P = 0.09$), not a rare event. Raising the low temperature to −17.2° C in Reno increased the cold periods to 27 in 42 years ($P = 0.64$) or a common annual event. Also, the −17.2° C was recorded in 43 of the 252 winter months ($P = 0.17$). Thus, Reno bees frequently experience cold temperatures but less frequently the extreme cold temperatures of the Logan, Utah area.

Little is known about the biology or physiology of overwintering in *O. l. propinqua* or for any solitary bee species (Krombein 1967, Michener 1972, Gauld & Bolton 1988). Thus, the effect of one period of extreme cold versus the accumulated effects of average colder winter temperatures are unknown. However, this study shows that Reno bees exposed to both colder minimum and colder average minimum temperatures did not survive to produce offspring and those that did survive were short lived and produced no offspring. A Reno population experiencing these winter minima should be severely reduced in size and should show selection for potentially more cold hardy individuals.

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